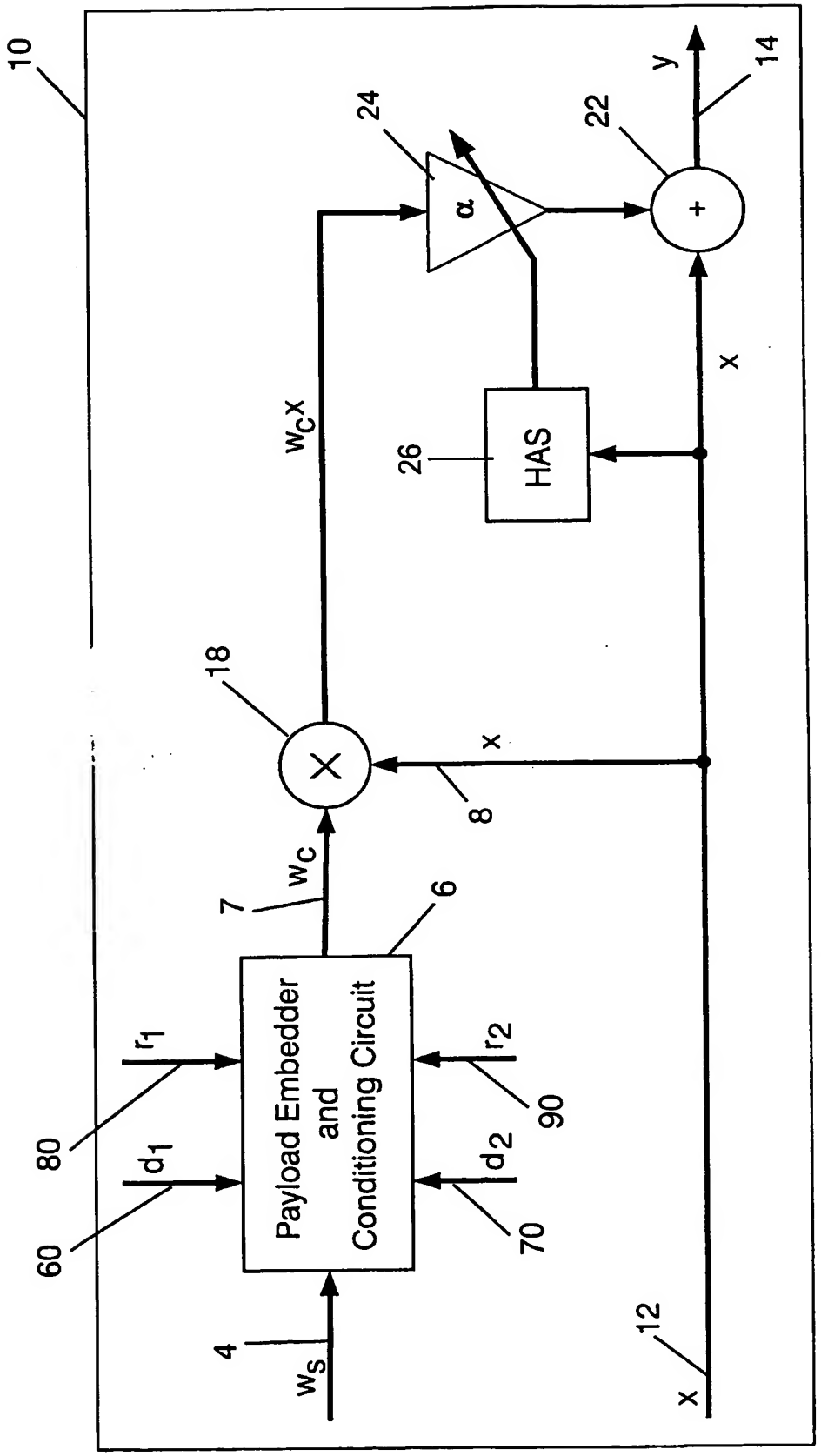

10
14
y
22
24
α
+
x
$w_c x$
26
HAS
18
x
8
w_c
7
6
Payload Embedder and Conditioning Circuit
r_1
80
d_1
60
r_2
90
d_2
70
4
w_s
12
x

FIG.1

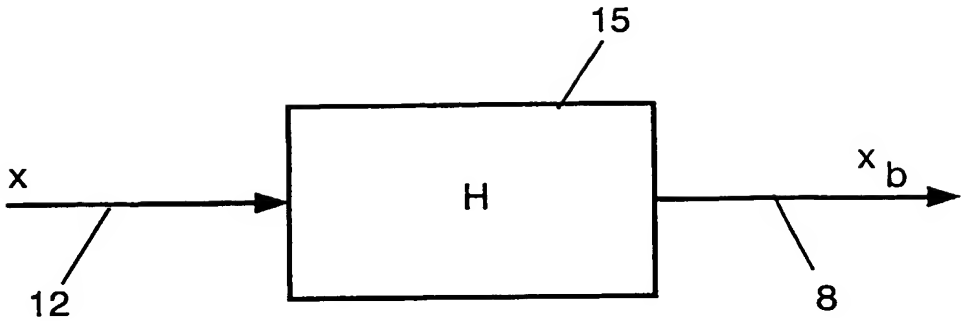

15
x
H
x b
12
8

FIG.2

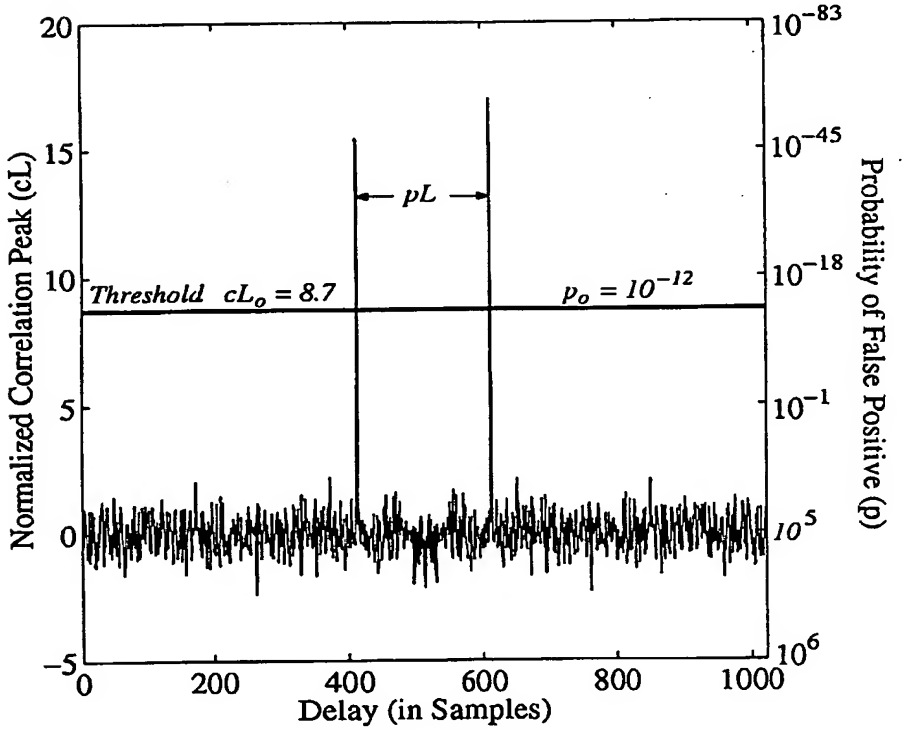

Normalized Correlation Peak (cL)
Probability of False Positive (p)
Delay (in Samples)
pL
Threshold $cL_o = 8.7$
$p_o = 10^{-12}$
20
15
10
5
0
−5
0
200
400
600
800
1000
10^{-83}
10^{-45}
10^{-18}
10^{-1}
10^{5}
10^{6}

FIG.11

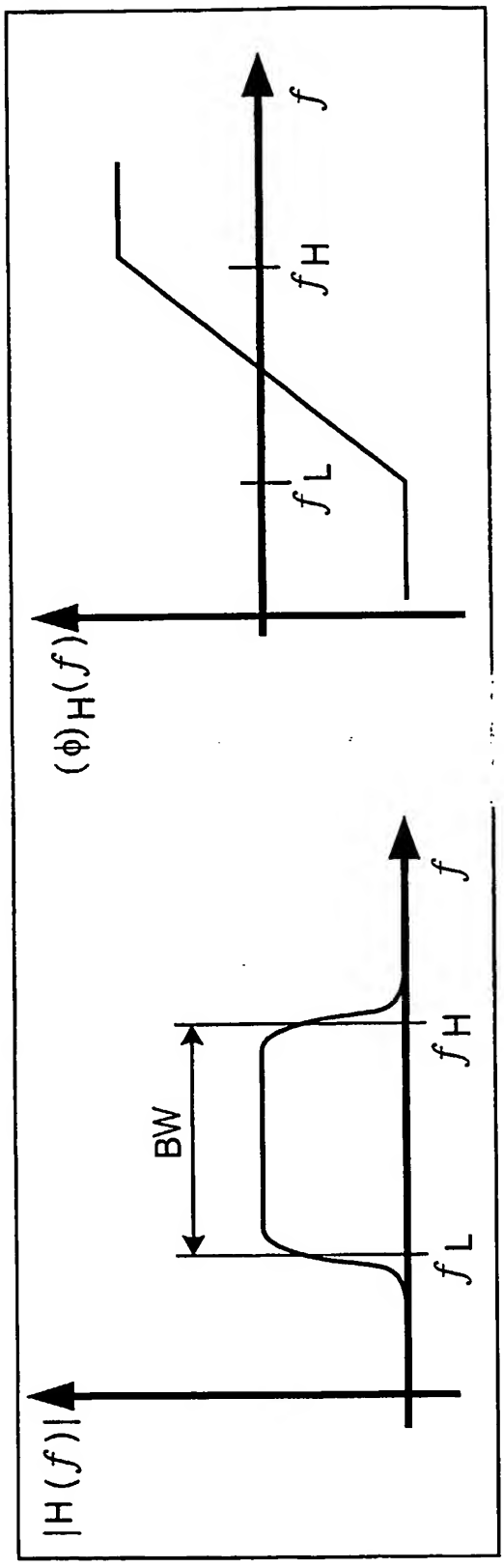


FIG.3b

FIG.3a

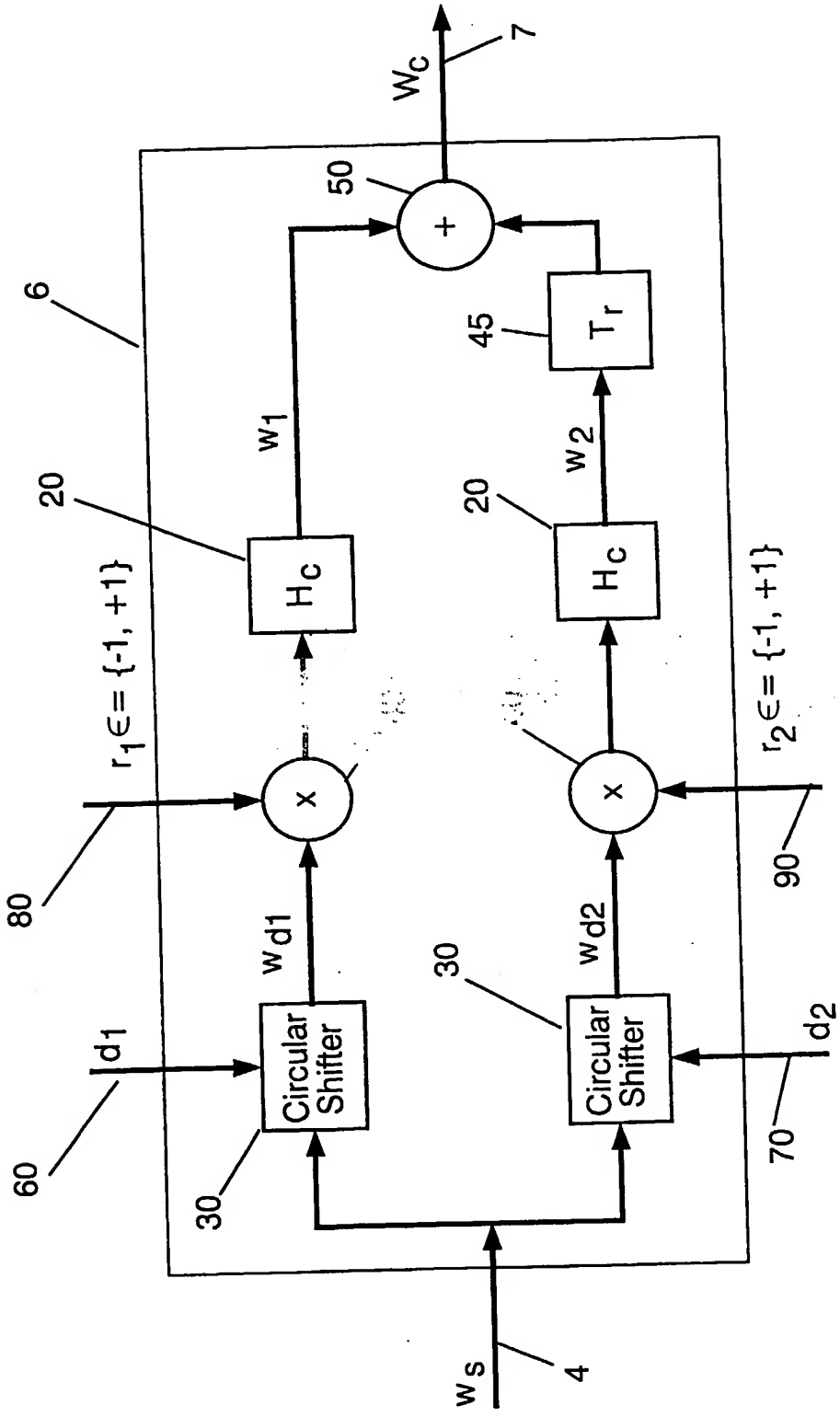

Wc
7
50
+
6
45
Tr
w1
w2
20
20
Hc
Hc
r1∈= {-1, +1}
r2∈= {-1, +1}
x
x
80
90
wd1
wd2
30
30
Circular Shifter
Circular Shifter
d1
d2
60
70
30
ws
4

FIG.4

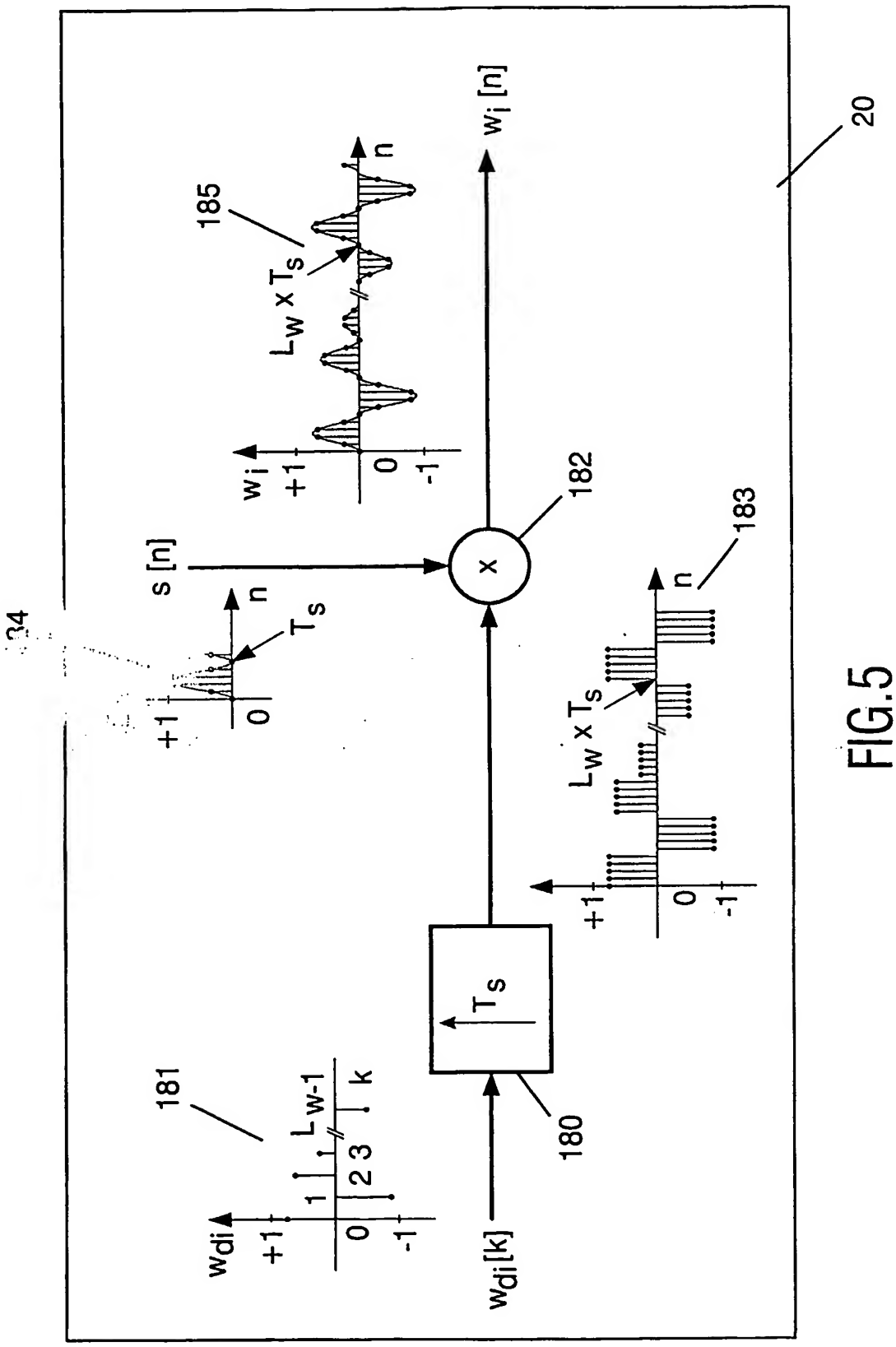

20
185
$L_W \times T_S$
w_i
+1
0
-1
n
w_i [n]
182
x
s [n]
24
T_S
183
$L_W \times T_S$
181
w_{di}
L_{W-1}
1
2 3
k
T_S
180
w_{di}[k]

FIG.5

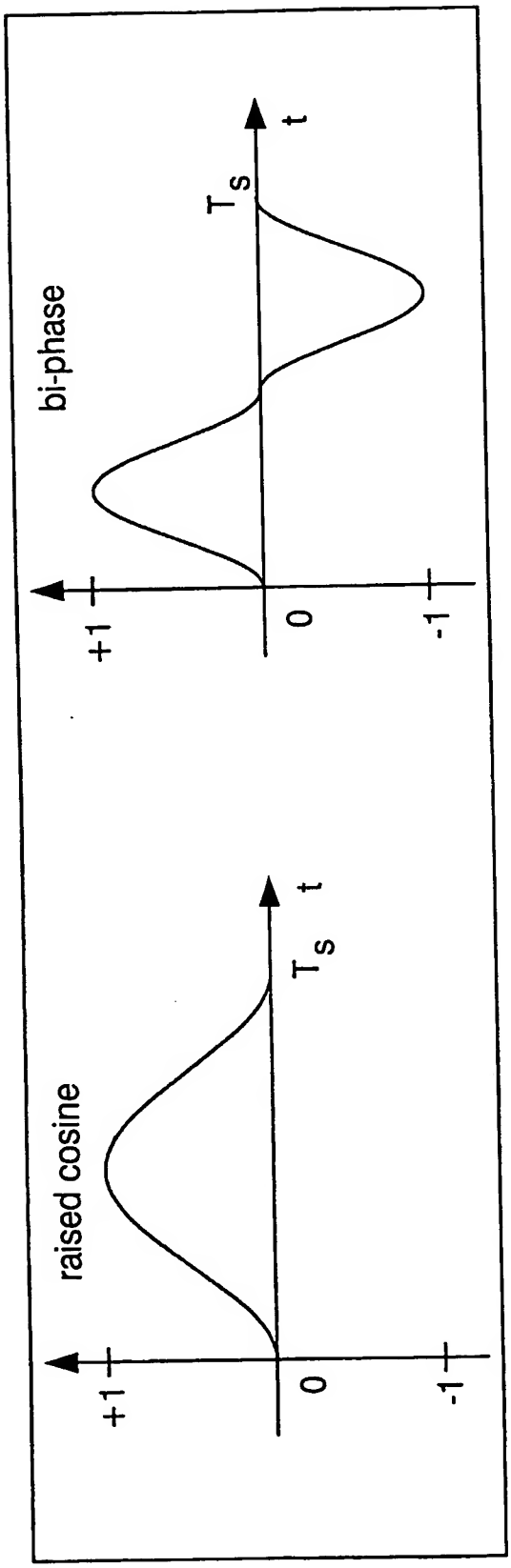


FIG.6b

FIG.6a

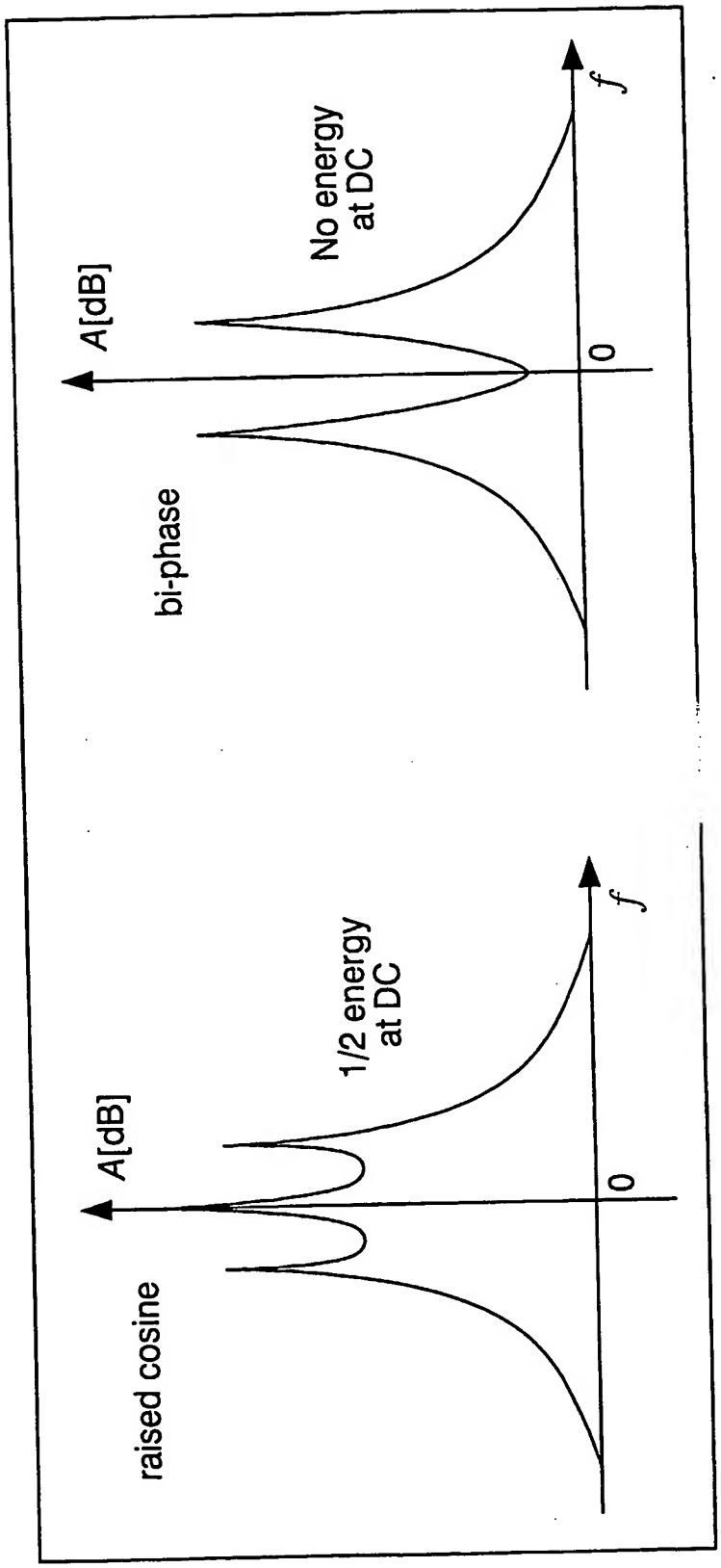

A[dB]
No energy at DC
f
0
bi-phase
A[dB]
1/2 energy at DC
f
0
raised cosine

FIG.7b

FIG.7a

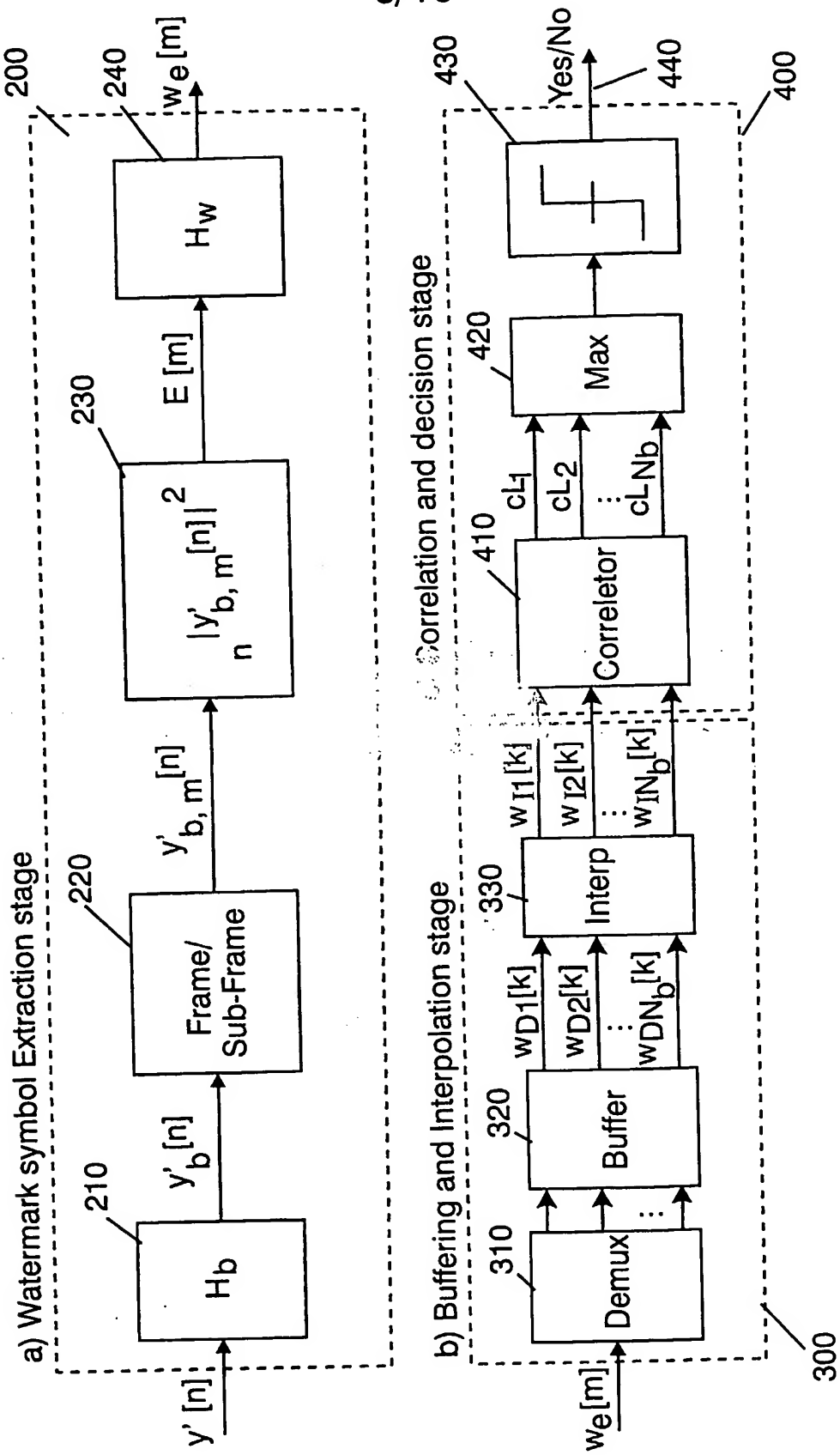

a) Watermark symbol Extraction stage
b) Buffering and Interpolation stage
Correlation and decision stage
200
210
220
230
240
300
310
320
330
400
410
420
430
440
Demux
Buffer
Interp
Correletor
Max
Frame/ Sub-Frame
Yes/No
y'[n]
y'b[n]
y'b, m[n]
E [m]
we[m]
wD1[k]
wD2[k]
wDNb[k]
wI1[k]
wI2[k]
wINb[k]
cL1
cL2
cLNb

FIG.8

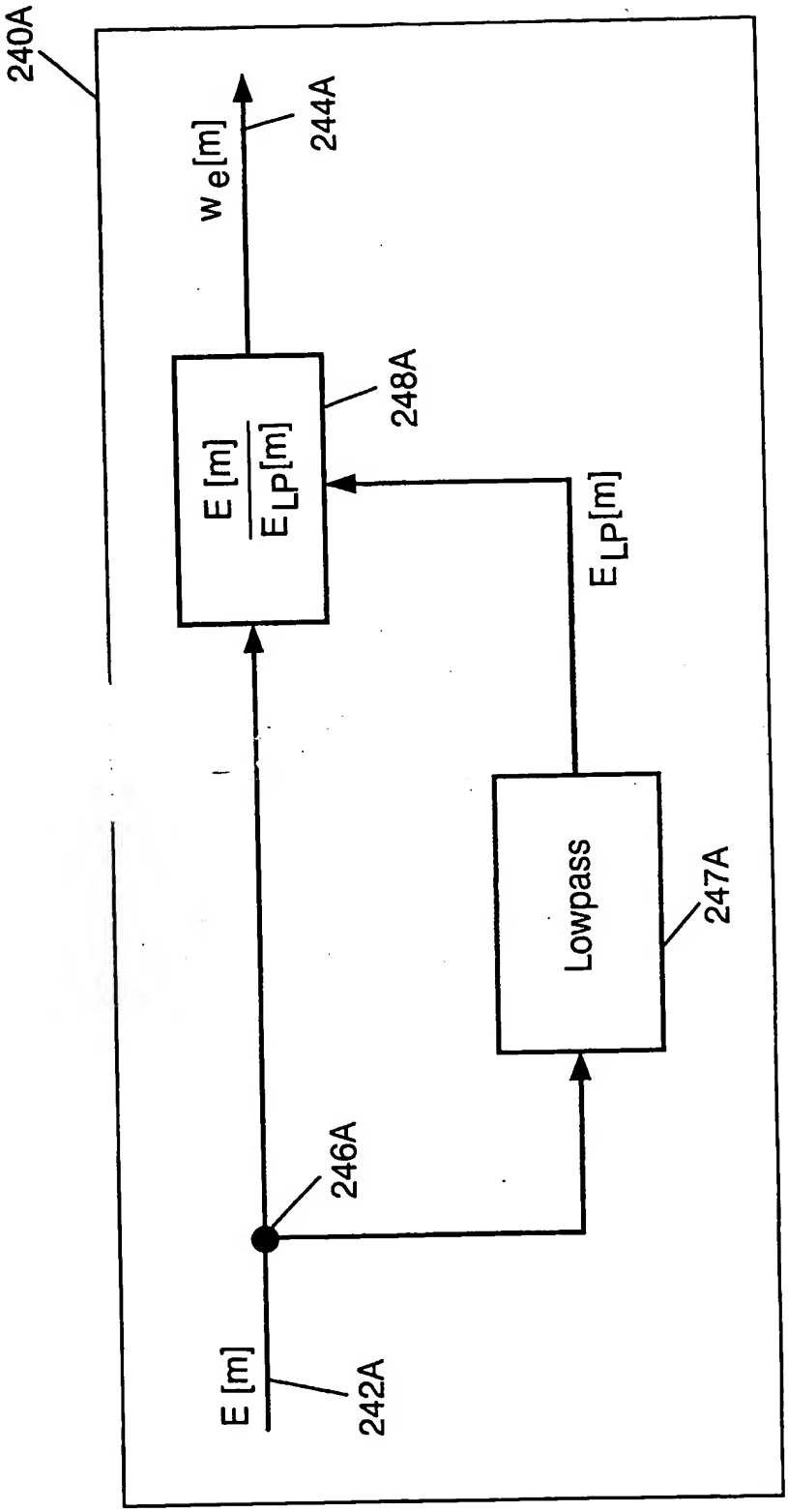
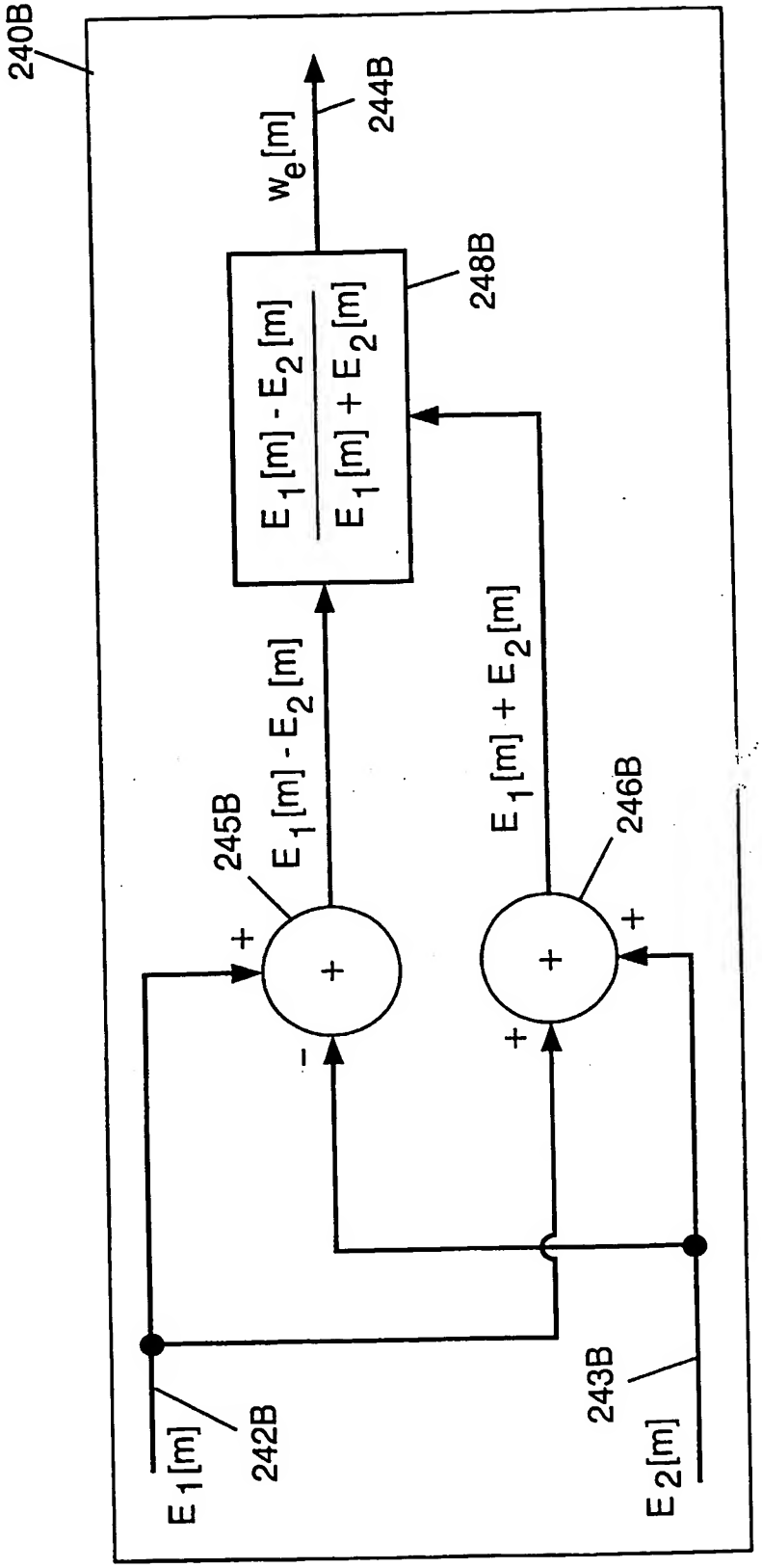

240A
$w_e[m]$
244A
$\frac{E[m]}{E_{LP}[m]}$
248A
$E_{LP}[m]$
Lowpass
247A
246A
E [m]
242A

FIG.9


240B
244B
$w_e[m]$
248B
$\frac{E_1[m] - E_2[m]}{E_1[m] + E_2[m]}$
245B
$E_1[m] - E_2[m]$
246B
$E_1[m] + E_2[m]$
+
+
-
+
+
242B
$E_1[m]$
243B
$E_2[m]$